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Hussey et al.

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(54) **RADIO FREQUENCY (RF) SIGNAL PATHWAY FOR A LAMP ANTENNA**

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(51) **Int. Cl.**

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H05B 33/00	(2006.01)
F21Y 101/02	(2006.01)
F21K 99/00	(2016.01)
F21S 8/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F21V 23/006*** (2013.01); ***H05B 33/00*** (2013.01); *F21K 9/135* (2013.01); *F21S 8/02* (2013.01); *F21Y 2101/02* (2013.01)

(58) **Field of Classification Search**

CPC F21Y 2101/02; F21V 23/006; F21S 8/02; F21K 9/135; F21K 9/1355

See application file for complete search history.

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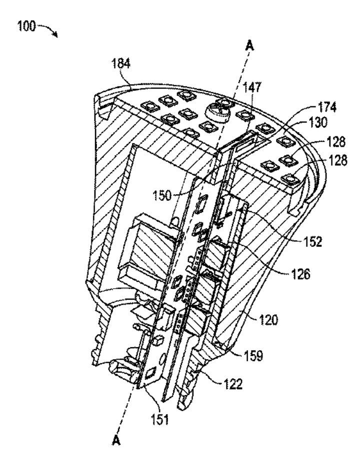
(57) **ABSTRACT**

An illumination device is disclosed, and includes a first housing defining an interior cavity and an aperture, at least one lighting element, and a driver board electrically coupled to the lighting element. The driver board includes an antenna element. The driver board is positioned at least in part within the interior cavity of the first housing. The aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the interior cavity of the first housing.

19 Claims, 10 Drawing Sheets



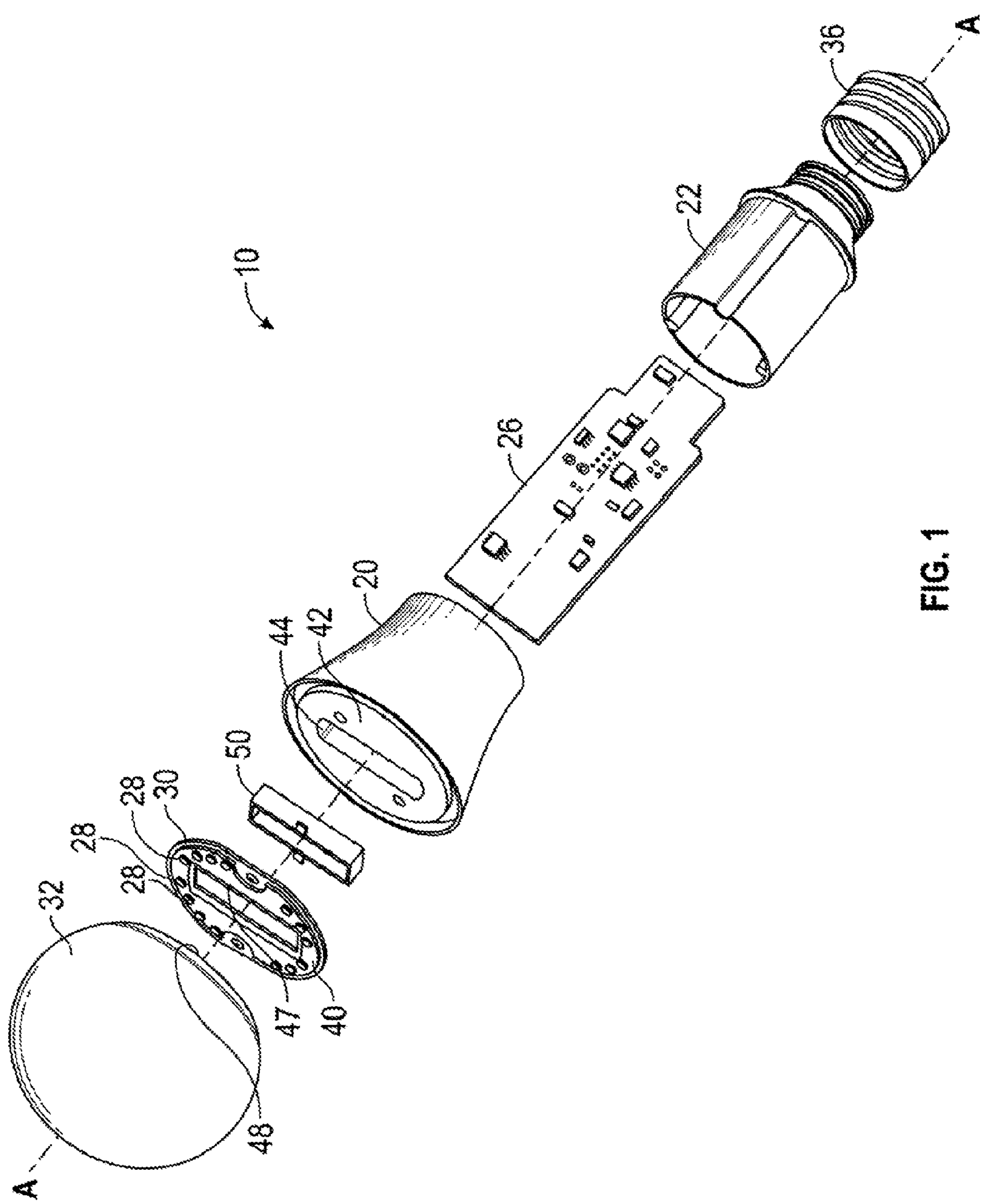


FIG. 1

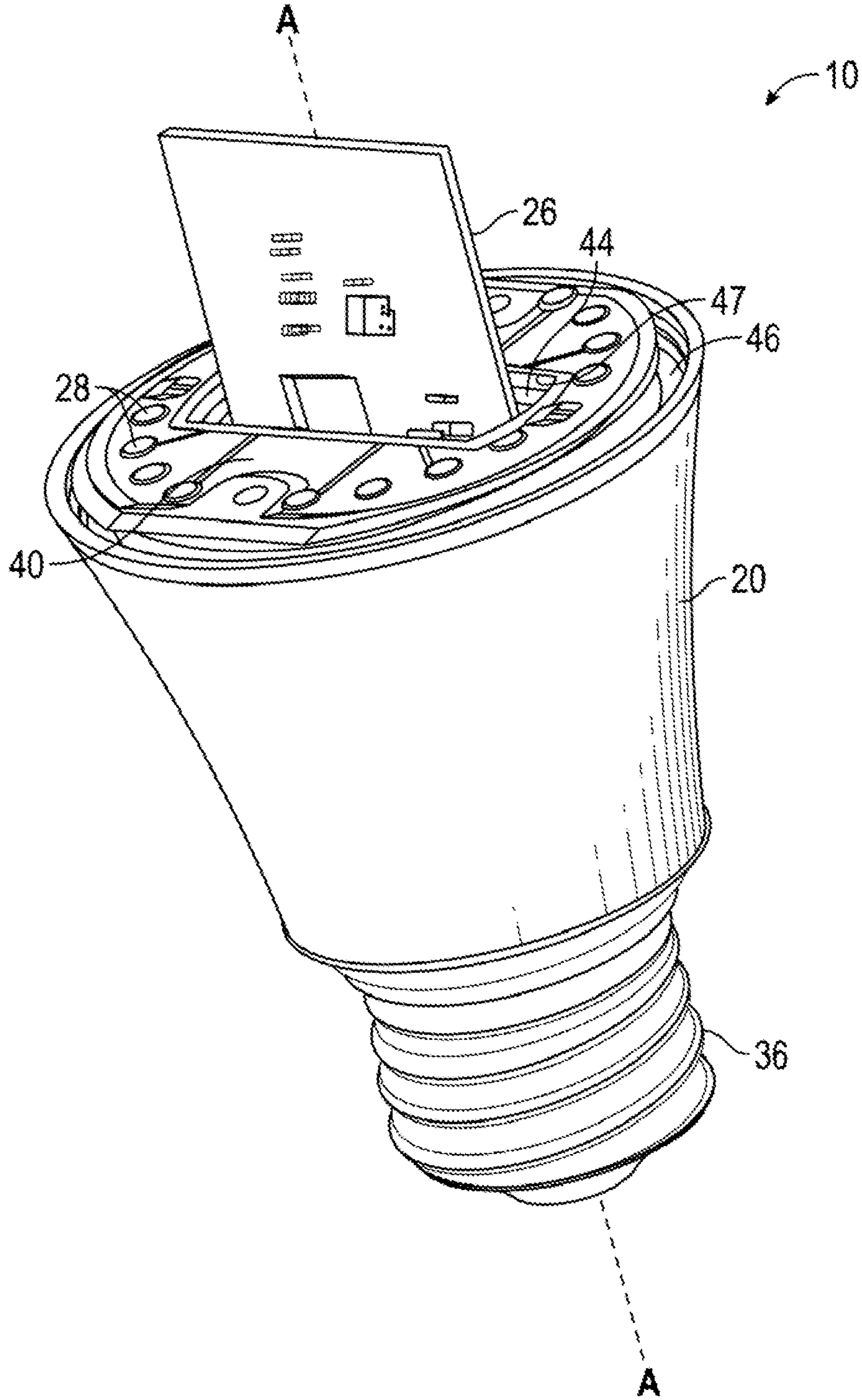


FIG. 2

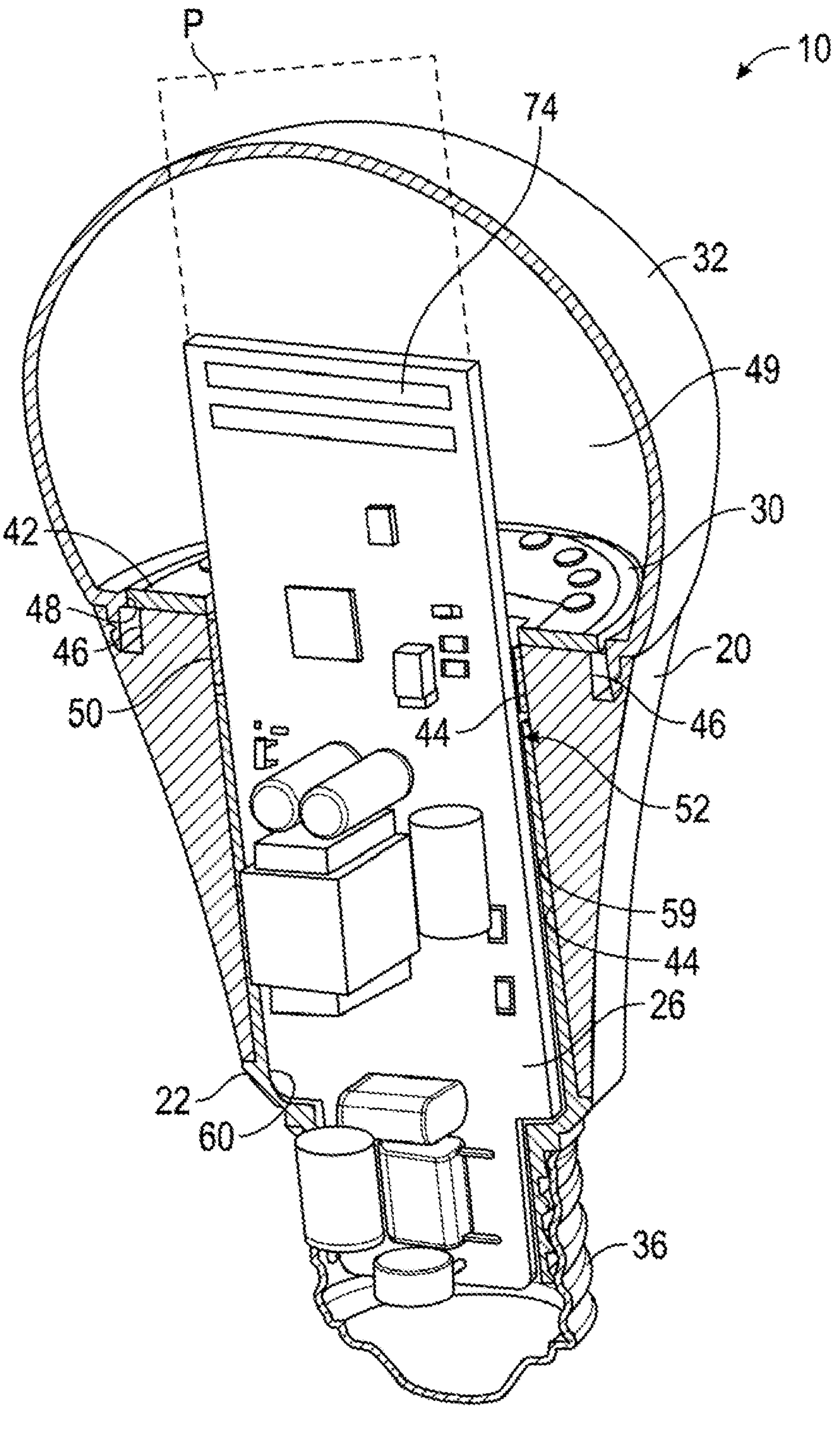


FIG. 3

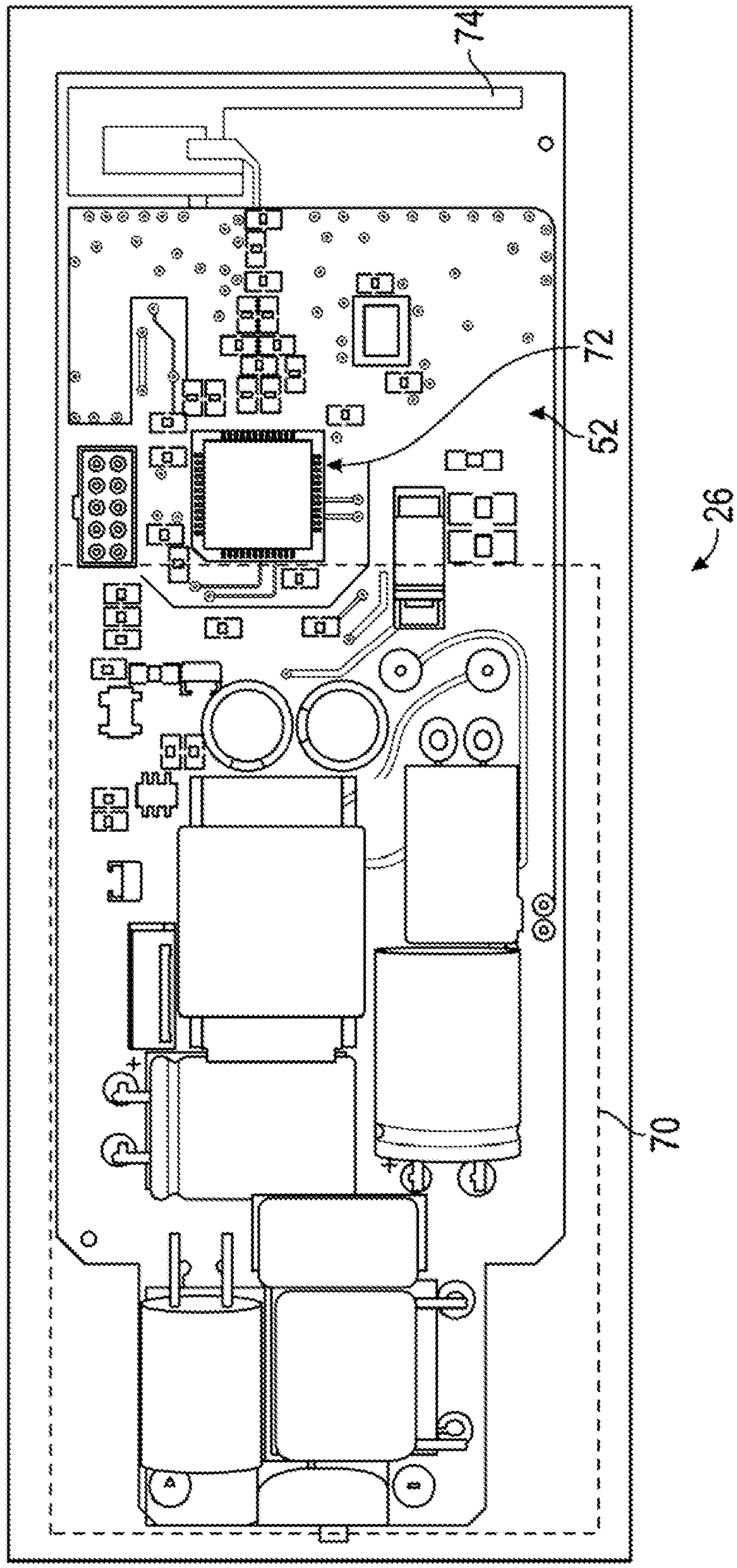


FIG. 4

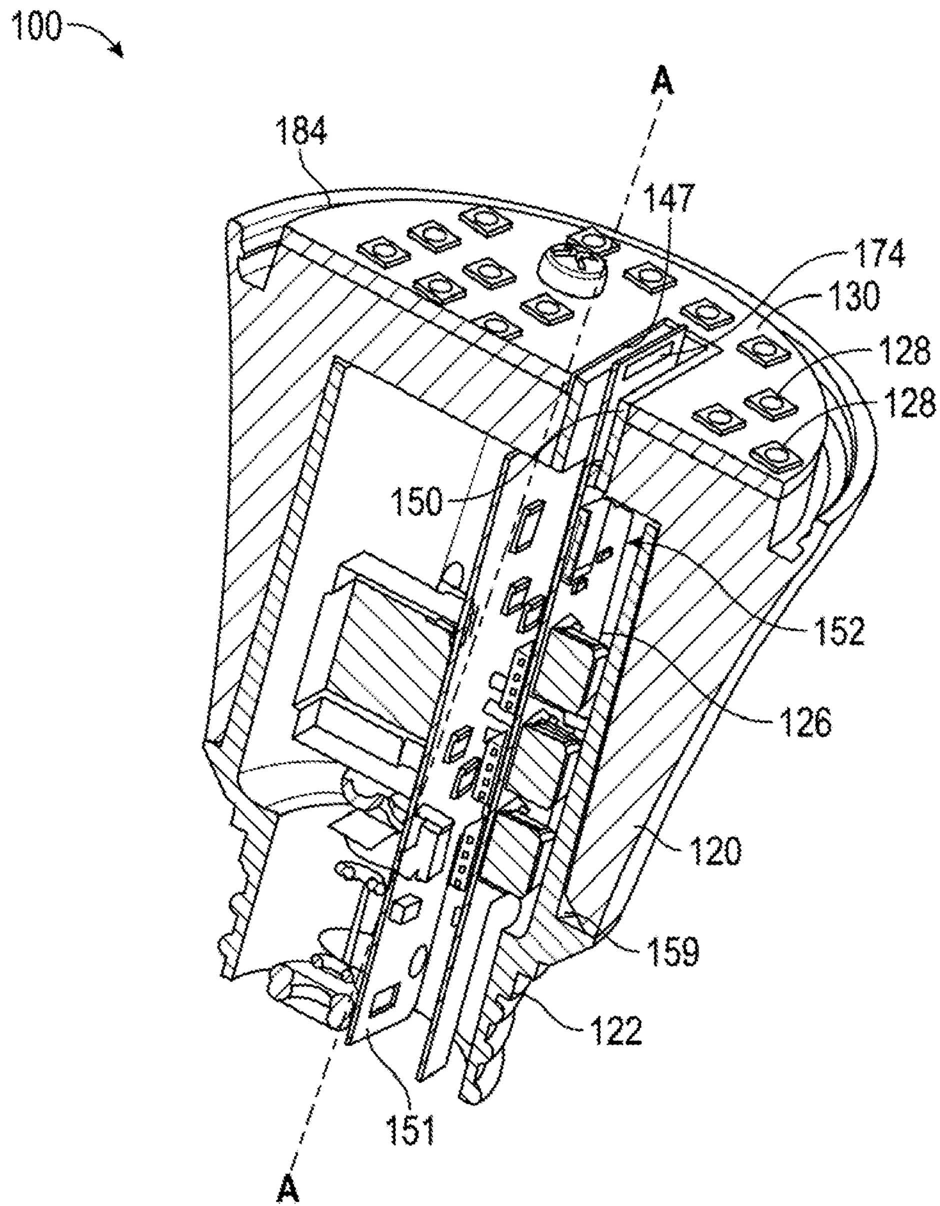


FIG. 5

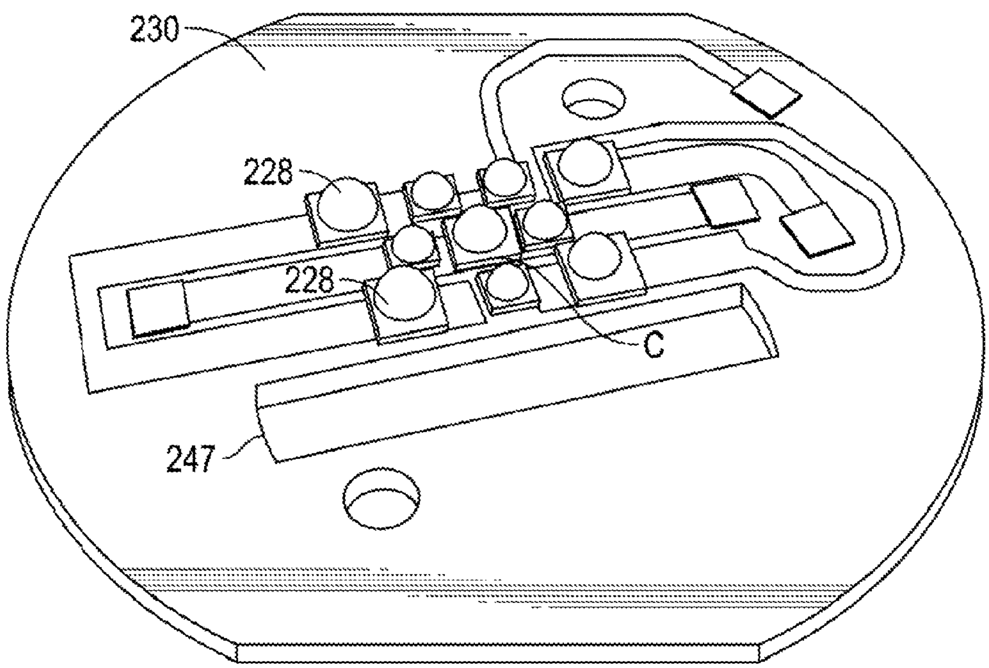


FIG. 6

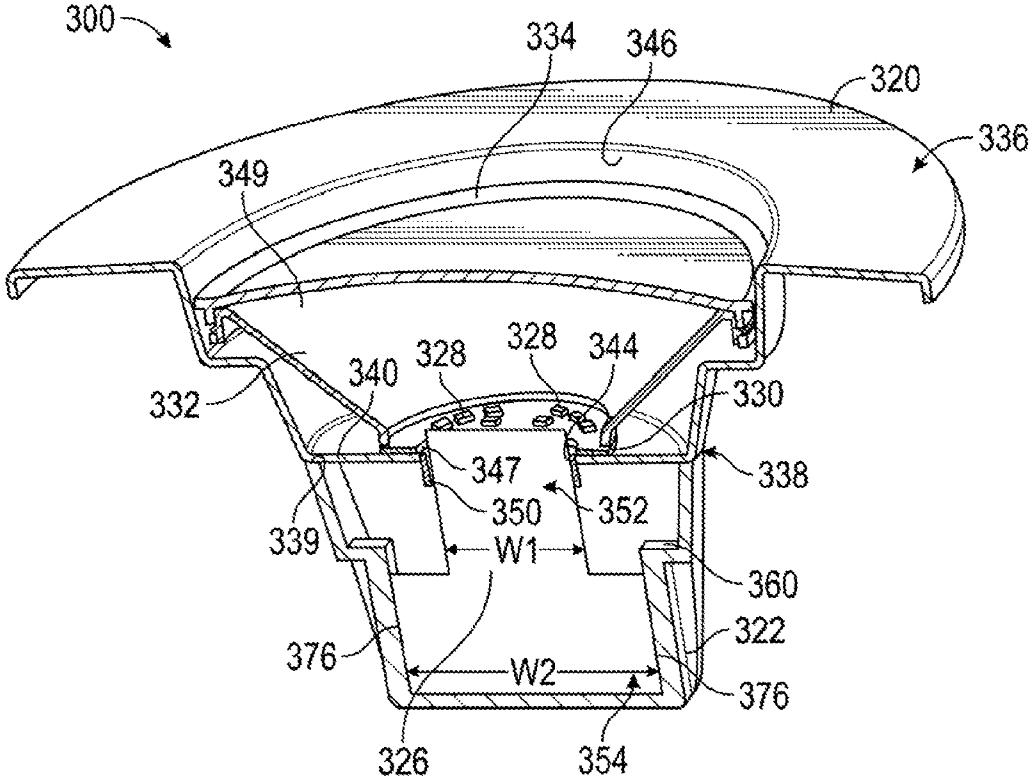

300
334
346
320
336
349
328
328
344
340
332
330
347
338
350
352
339
W1
360
322
376
W2
376
326
354

FIG. 7

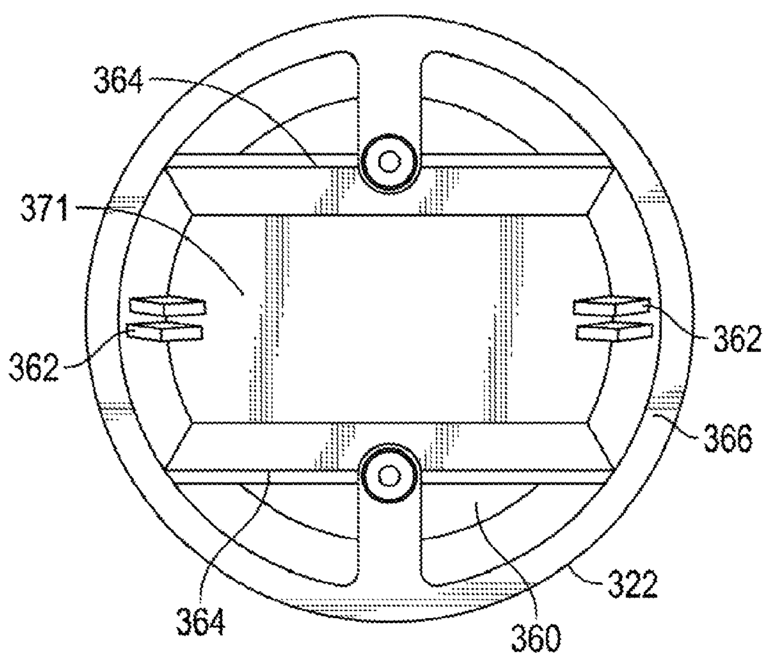

364
371
362
362
366
322
364
360

FIG. 8

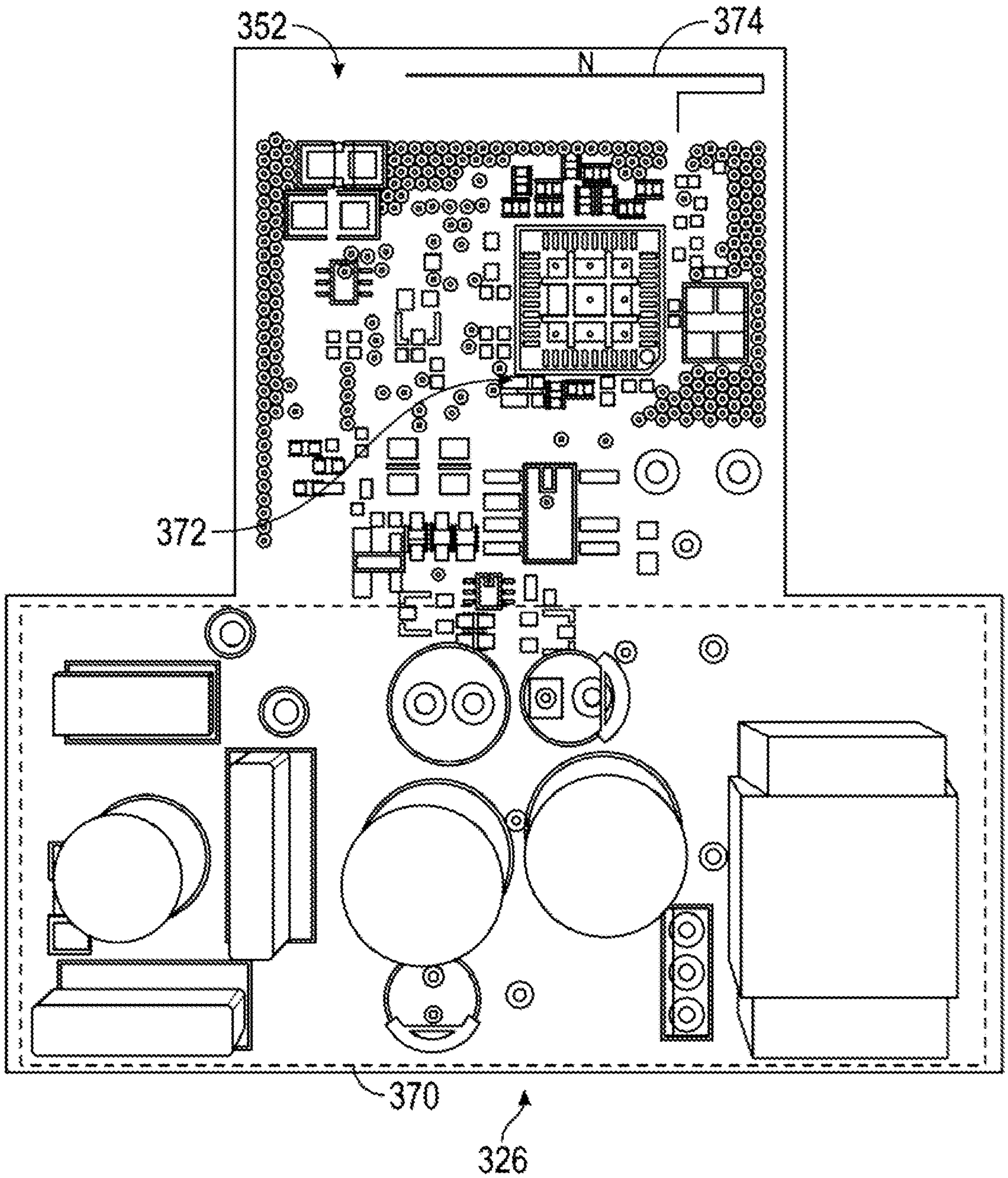


FIG. 9

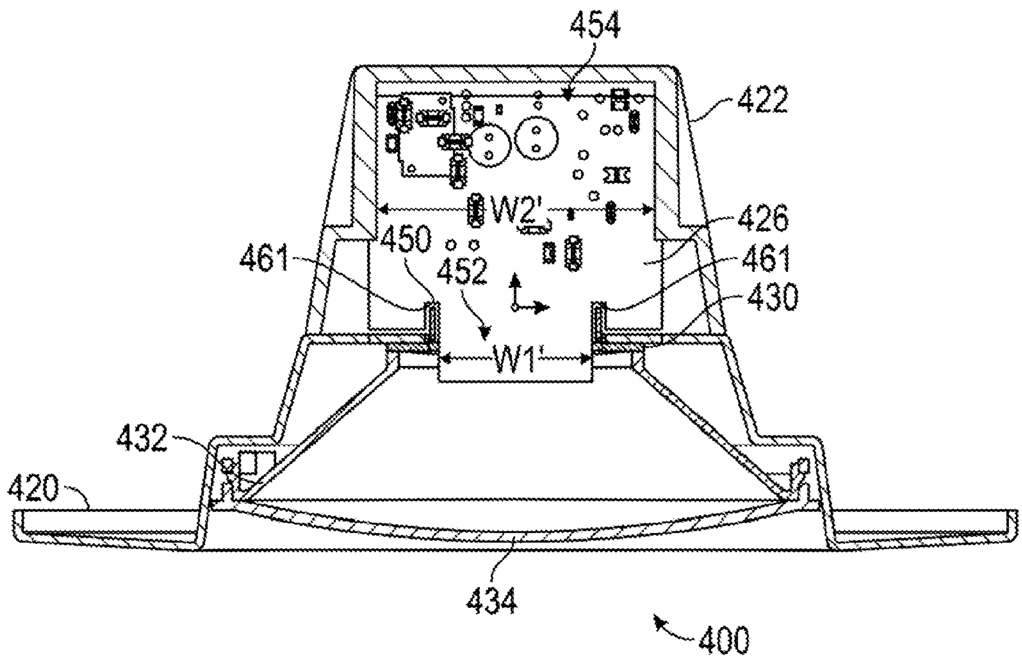


FIG. 10

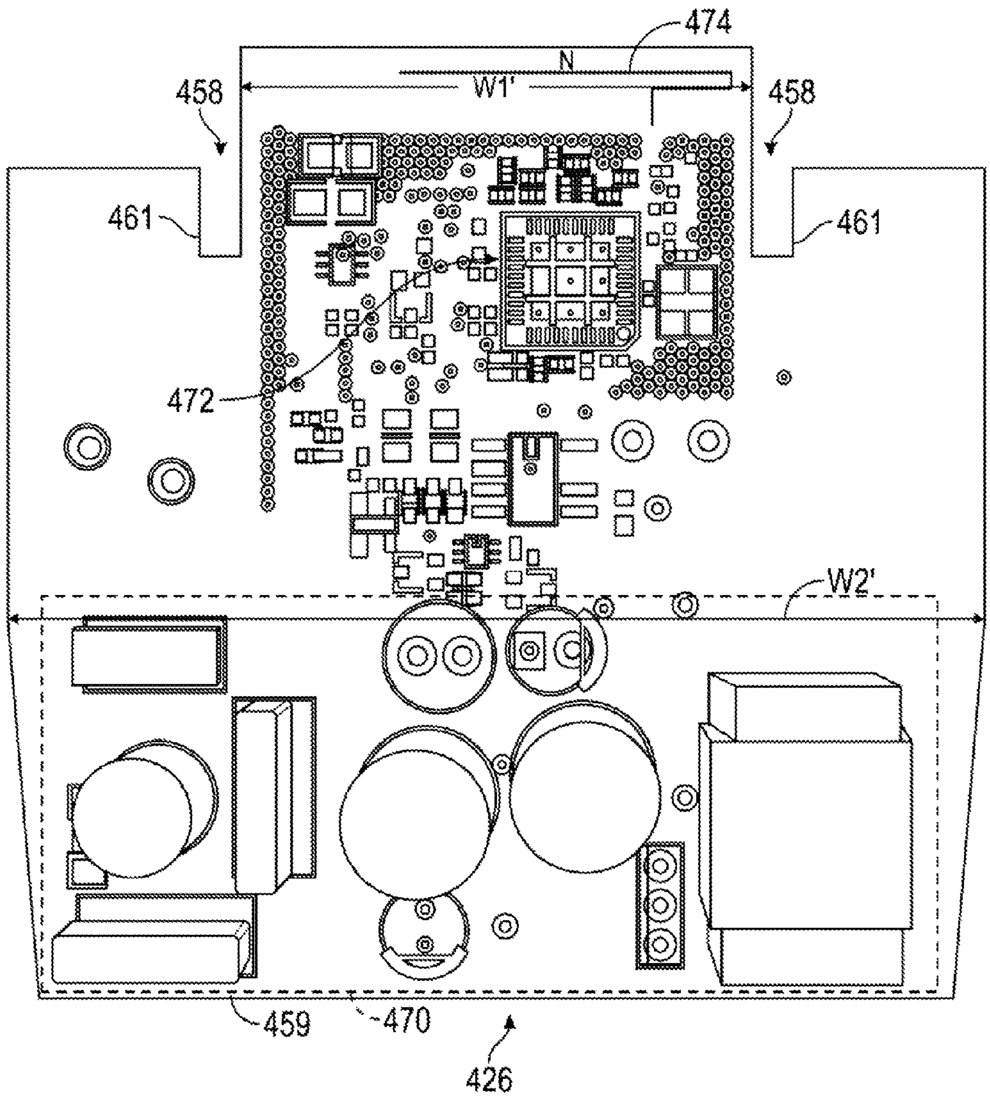


FIG. 11

RADIO FREQUENCY (RF) SIGNAL PATHWAY FOR A LAMP ANTENNA

TECHNICAL FIELD

The present disclosure relates generally to antenna elements for lamps, and more particularly to a lamp utilizing a housing defining an aperture, where the aperture is positioned to create a pathway such that radio frequency (RF) signals reach an interior cavity of the housing.

BACKGROUND

Wireless lighting control systems may utilize radio frequency (RF) communication to communicate control signals to an antenna element that is mounted on a driver board of a light fixture or bulb. For example, a user may turn on, turn off, or dim a light using wireless control. However, sometimes light fixtures include a housing that is constructed of a metallic material. The antenna element may be placed within or enclosed by the metallic housing. Thus, the metallic housing may act as an RF shield, which effectively blocks RF signals from reaching the antenna element. As a result, it may be difficult to wirelessly control the light, since the metallic housing significantly reduces the ability of RF signals to reach the antenna element.

In one attempt to improve RF reception within a lighting fixture, a three dimensional antenna such as, for example, a relatively small whip antenna may be soldered to the driver board of the lighting fixture. However, soldering the whip antenna to the driver board may substantially increase the labor and cost associated with the lighting fixture. Thus, there exists a continuing need in the art for a cost-effective antenna element that provides improved RF reception in an illumination device such as a light fixture or bulb.

SUMMARY

In one embodiment, an illumination device is disclosed. The illumination device includes a first housing defining an interior cavity and an aperture, at least one lighting element, and a driver board that is electrically coupled to the lighting element. The driver board includes an antenna element. The driver board is positioned at least in part within the interior cavity of the first housing. The aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the interior cavity of the first housing.

In another embodiment, a lighting fixture is disclosed and includes a first housing, a second housing, at least one lighting element, and a driver board. The first housing has an open end and a closed end, where an aperture is defined along a wall of the closed end. The second housing defines a cavity and an opening. The opening of the second housing is seated against the wall of the first housing. The driver board is electrically coupled to the lighting element and includes an antenna element. The driver board is positioned at least in part within the cavity of the second housing. The aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the interior cavity of the first housing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded view of an exemplary lamp;

FIG. **2** is a perspective view of the lamp shown in FIG. **1**;

FIG. **3** is a cross-sectioned view of the lamp shown in FIG. **1**;

FIG. **4** is an illustration of a driver board of the lamp shown in FIG. **1**;

FIG. **5** is a cross-sectioned view of an alternative embodiment of a lamp;

FIG. **6** is an alternative embodiment of a lighting element board for use in the lamp shown in FIG. **5**;

FIG. **7** is a cross-sectioned view of an exemplary downlight fixture;

FIG. **8** illustrates an interior of a second housing of the downlight fixture shown in FIG. **7**;

FIG. **9** is an illustration of a driver board of the downlight fixture shown in FIG. **7**;

FIG. **10** is a cross-sectioned view of an alternative embodiment of a downlight fixture; and

FIG. **11** is an illustration of a driver board of the downlight fixture shown in FIG. **10**.

DETAILED DESCRIPTION

The following detailed description will illustrate the general principles of the invention, examples of which are additionally illustrated in the accompanying drawings. In the drawings, like reference numbers indicate identical or functionally similar elements.

FIGS. **1-2** illustrate an exemplary lamp **10**. The lamp **10** may include a first housing **20**, a sleeve or second housing **22**, a driver board **26**, a one or more lighting elements **28**, a lighting element board **30**, an optic element **32**, and a socket base **36**. In the embodiment as shown, the lighting elements **28** are disposed along an upper surface **40** of the lighting element board **30**. The lighting elements **28** may be light emitting diodes (LEDs). Those skilled in the art will appreciate that although the lamp **10** is illustrated as a type A light bulb, the disclosure should not be limited to a specific type of lamp. Indeed, any type of illumination device that is configured to transmit visible light may be used as well such as, for example, a recessed downlight fixture. Moreover, although an LED bulb is illustrated, it is to be understood that the disclosure is not limited to LED lighting, and may be applied to other types of lighting as well such as, but not limited to, fluorescent tube lighting or a compact fluorescent lighting (CFL).

In one non-limiting embodiment, the first housing **20** may be constructed of a heat-conducting metal such as, for example, aluminium or a metal alloy. Alternatively, in another embodiment, the first housing **20** may be constructed of a thermally conductive plastic. One commercially available example of a thermally conductive plastic is sold under the trade name THERMA-TECH, and is available from the PolyOne Corporation of Avon Lake, Ohio. The second housing **22** may be constructed of any type material that is an electrical insulator that allows for radio frequency (RF) signals to pass through such as, but not limited to, plastic. For example, in one embodiment the second housing **22** may be constructed from acrylonitrile butadiene styrene (ABS).

Referring to FIGS. **1-3**, the first housing **20** may include a centrally located aperture **44** and a recess **46** disposed along a top surface **42** of the first housing **42**. Specifically, the aperture **44** may be located at a central axis A-A of the lamp **10**. The lighting element board **30** may also include a centrally located aperture **47** that corresponds with the aperture **44** of the first housing **20**. Referring specifically to FIG. **3**, the recess **46** of the first housing **20** is shaped to receive an opening **48** of the optic element **32**. Specifically, when the lamp **10** is assembled, the opening **48** of the optic element **32** may be seated within the recess **46** of the first housing **20**.

The optic element **32** may be an enclosure that defines a lighting cavity **49**. As seen in FIG. **3** the lighting elements **28** and the lighting element board **30** are enclosed and surrounded by the optic element **32** when the lamp **10** is assembled. The optic element **32** may be constructed of any substantially transparent or translucent material that allows for light to pass therethrough. For example, the optic element **32** may be constructed of a plastic such as polycarbonate. In an alternative embodiment, the optic element **32** may be constructed from glass.

Referring to both FIGS. **1** and **3**, an insert ring **50** may be shaped to fit within the aperture **44** of the first housing **20**. The insert ring **50** may be constructed of an electrical insulator such as, for example, plastic. The insert ring **50** may be placed within the aperture **44** of the first housing **20**. As seen in FIG. **3**, an upper end portion **52** of the driver board **26** may be received by the insert ring **50**. In other words, the insert ring **50** may surround the upper end portion **52** of the driver board **26**. The insert ring **50** may be used to provide electrical insulation between the driver board **26** and the first housing **20** (if the first housing **20** is constructed of metal) as well as the lighting element board **30**.

FIG. **4** is an illustration of the driver board **26**. The driver board **26** may include various power electronics **70**, a microcontroller and radio **72**, and an antenna element **74**. In one embodiment, the driver board **26** may be a printed circuit board (PCB). In an embodiment, the antenna element **56** may be positioned along the upper end **52** of the driver board **26**. Positioning the antenna element **56** along or proximate to the upper end **52** of the driver board **26** may decrease RF signal attenuation, and is explained in greater detail below. Although positioning the antenna element **74** along the upper end portion **52** of the driver board **26** is discussed, it is to be understood is not limited to this configuration, and that the antenna element **74** may be positioned anywhere along the driver board **26**. The driver board **26** is electrically coupled and delivers power to the lighting elements **28** (shown in FIG. **3**). In one embodiment, at least a portion of the driver board **26** may be coated with a white solder mask. In particular, referring to both FIGS. **3** and **4**, the upper end **52** of the driver board **26** may project or extend out of the aperture **44** of the first housing **20**, and extend into the lighting cavity **49**. If the portion of the driver board **26** that is located within the lighting cavity **49** is coated with a white solder mask, this improves light transmission since the white solder mask reflects light.

Referring to FIG. **4**, the driver board **26** is illustrated a PCB and the antenna element **74** is illustrated a trace antenna. However, those skilled in the art will appreciate that the disclosure is not limited to a trace antenna and PCB. In one embodiment, the antenna element **74** may be configured to receive a short-range RF signal such as, for example, a Bluetooth® signal conforming to IEEE Standard 802.15. Moreover, although only one antenna element **74** is discussed, those skilled in the art will readily appreciate that more than antenna element may also be included on the driver board **26** as well in order to receive RF signals of varying frequencies. Alternatively, in another embodiment, the antenna element **74** may be a multi-band antenna that operates at different RF frequency bands.

Referring to FIG. **3**, the first housing **20** may define an internal cavity **59**. The internal cavity of the first housing **59** may be configured to receive at least a portion of the second housing **22** as well as the driver board **26**. The second housing **22** may also define a cavity **60** that is configured to receive the driver board **26**. The driver board **26** is oriented within the cavity **60** of the second housing **22** such that RF signals may reach the antenna element **74** without substantial obstruction by an element that effectively block RF signals. Specifically, in the embodiment as shown in FIG. **3**, the driver board **26** projects outwardly from the aperture **44** of the first housing **20** such that the antenna element **74** is positioned within the lighting cavity **49**. However, while FIG. **3** illustrates the antenna element **74** located within the lighting cavity **49**, it is to be understood that in some embodiments the antenna element **74** may be positioned along the driver board **26** such that the antenna element **26** is located within the second housing **20**. However, those skilled in the art will readily appreciate that if the first housing **20** is contracted of a material that effectively blocks RF signals (e.g., aluminium), then placing the antenna element **74** within the lighting cavity **49** may decrease antenna attenuation.

Continuing to refer to FIG. **3**, in one embodiment a vertical plane P of the driver board **26** is substantially aligned with the aperture **44** of the first housing **20**. Thus, the aperture **44** of the first housing **20** creates a pathway for RF signals to travel into the interior cavity **59** of the first housing **20**. Therefore, in the event the first housing **20** is constructed from a material that effectively blocks RF signals, it is still possible for RF signals to reach the antenna element **74**, even if the antenna element **74** is located within the internal cavity **59** of the first housing **20**.

FIG. **5** is an alternative embodiment of a lamp **100**. Similar to the embodiment as shown in FIGS. **1-4** and described above, the lamp **100** may include a first housing **120**, a sleeve or second housing **122**, a first driver board **126**, a one or more lighting elements **128**, a lighting element board **130**, an optic element (not illustrated), and an insert ring **150**. Additionally, the lamp **100** may also include a second driver board **151** that is offset in a generally horizontal direction from the first driver board **126**. The second driver board **151** may be used in the event that all of the electronics (e.g., the power electronics **70**, microcontroller and radio **72**, and the antenna element **74** as seen in FIG. **4**) may not be able to fit on a single driver board. Sometimes the lamp **100** may not be able to accommodate a relatively large driver board due to packaging constraints. Therefore, two driver boards may be used instead to accommodate all of the electronics associated with powering the lighting elements **128**.

Similar to the embodiment as described above and shown in FIGS. **1-4**, an antenna element **174** may be disposed along an upper end portion **152** of the driver board **126**. Specifically, the antenna element **174** projects outwardly from the aperture **144** of the first housing **20**. Although FIG. **5** illustrates the antenna element **174** positioned along the upper end portion **152** of the driver board **126**, it is to be understood that the antenna element **174** may be positioned anywhere along the driver board **126**. Moreover, it is also understood that the antenna element **174** may also be positioned along the second driver board **151** as well.

As seen in FIG. **5**, the second driver board **151** may be substantially enclosed within an interior cavity **159** of the first housing **120**. However, the aperture **144** of the first housing **120** creates a pathway for RF signals to travel into the interior cavity **159** of the first housing **120**. Therefore, in the event the first housing **120** is constructed from a material that effectively blocks RF signals, it is still possible for RF signals to reach the antenna element **174**, even if the antenna element **174** is located along the second driver board **151**.

In the embodiment as shown in FIG. **5**, the lamp **100** may include an offset design. Specifically, unlike the embodiment as shown in FIG. **2**, the aperture **144** of the first housing **120** as well as an aperture **147** of the lighting element board **130** may both be offset from the central axis A-A of the lamp **100**. Therefore, the upper end portion **152** of the driver board **126** may also be offset from the central axis A-A of the lamp **100**. In the embodiment as shown in FIG. **5**, the lighting elements **128** may be disposed along an outer periphery **184** of the lighting element board **130**. FIG. **6** is an alternative embodiment the lighting element board **230**. Similar to the embodiment as shown in FIG. **5**, the lighting board **230** may include an aperture **247** that is offset from the central axis A-A. However, the lighting element board **230** may also include a plurality of lighting elements **228** that are grouped at or around a center C of the lighting element board **230**. Positioning the lighting elements **228** around the center C of the lighting element board **228** may be beneficial. Specifically, for example, placing the lighting elements **228** around the center C may provide enhanced light output and color temperature mixing.

FIG. **7** illustrates an exemplary downlight fixture **300**. The downlight fixture **300** may include a first housing **320**, a second housing **322**, a driver board **326**, one or more lighting elements **328**, a lighting element board **330**, an optic element **332**, and a cover **334**. Similar to the embodiments as described above and shown in FIGS. **1-6**, the first housing **320** may be constructed of a heat-conducting metal or a thermally conductive plastic. The second housing **322** may be constructed of any type material that is an electrical insulator that allows for RF signals to pass through such as, but not limited to, plastic. The first housing **320** is positioned over the second housing **322**. When the downlight fixture **300** is installed in a ceiling (not illustrated), the first housing **320** is typically exposed, and the second housing **322** is recessed within the ceiling.

The first housing **320** may include a open upper end **336** and a closed lower end **338**. A wall **340** may be located at the lower end **338** of the first housing **320**. An opening **339** of the second housing **322** may be seated against the wall **340** of the first housing **320**. A centrally located aperture **344** may be disposed along the wall **340** of the first housing **320**. The lighting element board **330** may also include a centrally located aperture **347** that corresponds with the aperture **344** of the first housing **320**. The optic element **332** as well as the cover **334** may both be secured to the first housing **320**. Specifically, the optic element **332** may be seated within a recess **346** of the first housing **320**. The optic element **332** and the cover **334** may cooperate together to create an enclosure that defines a lighting cavity **349**.

The downlight fixture **300** may also include an insert ring **350** shaped to fit within the aperture **344** of the first housing **320**. An upper end portion **352** of the driver board **326** may be received by the insert ring **350**. Similar to the embodiments as described above and shown in FIGS. **1-6**, the insert ring **350** may be used to provide electrical insulation between the driver board **326** and the first housing **320** (if the first housing **320** is constructed of metal) as well as the lighting element board **330**.

The driver board **326** may include the upper end portion **352** and a lower end portion **354**. In the embodiment as shown, the upper end portion **352** include a first width **W1** and the lower end portion **354** includes a second width **W2**. The first width **W1** is less than the second width **W2** such that the driver board **326** may have a generally T-shaped profile. The second width **W2** of the driver board **326** may be sized so as to correspond with one or more positioning features (shown in FIG. **8** as a two opposing slots **362**) located within a cavity **360** of the second housing **322**. FIG. **8** illustrates the cavity **360** of the second housing **322**. As seen in FIG. **8**, the cavity **360** may include two opposing slots **362** located on opposing sides of the cavity **360**. The two opposing slots **362** may be locating features that are used to position the driver board **326** (not shown in FIG. **8**) in place within the cavity **360** of the second housing **322**. The cavity **360** also includes two generally opposing walls **364** that cooperate with an outer wall **366** of the second housing **322** to create a potting chamber **371**.

Referring to both FIGS. **7** and **8**, the second width **W2** of the driver board **322** may be sized such that the two opposing slots **362** may slidingly receive a side **376** of the driver board **326**. Once the driver board **326** is placed within the two opposing slots **362**, a potting material (not shown) may be placed within the potting chamber **371** to secure the driver board **326** in place within the cavity **360** of the second housing **322**.

FIG. **9** is an illustration of the driver board **326**. The driver board **326** may include various power electronics **370**, a microcontroller and radio **372**, and an antenna element **374**. In an embodiment, the antenna element **356** may be positioned along the upper end portion **352** of the driver board **326**. However, similar to the embodiments as described above, it is to be understood that the antenna element **374** may be positioned anywhere along the driver board **326**. Referring to FIGS. **7** and **9**, the driver board **326** projects outwardly from the aperture **344** of the first housing **320** such that the antenna element **374** is positioned within the lighting cavity **349**. Similar to the embodiments as described above, the aperture **344** of the first housing **320** creates a pathway for RF signals to travel into the interior cavity **360** of the second housing **322**. Therefore, in the event the first housing **320** is constructed from a material that effectively blocks RF signals, it is still possible for RF signals to reach the antenna element **374**, even if the antenna element **374** is located within the cavity **360** of the second housing **322**.

FIG. **10** is an alternative embodiment of a downlight fixture **400**. The downlight fixture **400** may include a first housing **420**, a second housing **422**, a driver board **426**, one or more lighting elements (not visible in FIG. **10**), a lighting element board **430**, an optic element **432**, a cover **434**, and an insert **450**. Similar to the embodiment as shown in FIG. **10**, the driver board **426** includes an upper end portion **452** and a lower end portion **454**, where the upper end portion **452** includes a first width **'W1** and the lower end portion **454** includes a second width **'W2**. The first width **'W1** is less than the second width **'W2**. As seen in FIG. **11**, the lower end portion **454** of the driver board **426** may include a tapered configuration.

Referring to FIG. **11**, similar to the embodiments as described above, the driver board **426** may include various power electronics **470**, a microcontroller and radio **472**, and an antenna element **474**. The driver board **426** may also include two shoulder areas **458** located along outer perimeter **459** of the driver board **426**. The shoulder areas **458** represent where the first width **'W1** transitions into the second width **'W2**. In the embodiment as shown, the first width **'W1** transitions into the second width **'W2** using a stepped configuration, which creates the two shoulder areas **458**. A notch **461** may be located along each shoulder area **458** of the driver board **426**. Referring to both FIGS. **10-11**, the notches **461** may be shaped to receive a portion of the insert **450**. The notches **462** may be used to secure driver board **426** in place within the second housing **422**.

Referring generally to the figures, the disclosed lamps and lighting fixtures may include improved RF reception when compared to some types of illumination devices currently available. This is because the first housing, which may be a heat sink, includes an aperture that creates a pathway for RF signals to travel into an interior cavity of the first housing. Therefore, in the event the first housing is constructed from a material that effectively blocks RF signals such as, for example, aluminum it is still possible for RF signals to reach the antenna element. This is true even if the antenna element is buried or encased within the first housing.

While the forms of apparatus and methods herein described constitute preferred embodiments of this invention, it is to be understood that the invention is not limited to these precise forms of apparatus and methods, and the changes may be made therein without departing from the scope of the invention.

What is claimed is:

1. An illumination device, comprising:

a first housing defining an interior cavity and an aperture along a top surface of the first housing;

at least one lighting element; and

a driver board electrically coupled to the at least one lighting element and including an antenna element disposed along a surface of the driver board, wherein the driver board is positioned at least in part within the interior cavity of the first housing and the antenna element is located within the interior cavity of the first housing, and wherein the aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the interior cavity of the first housing and are received by the antenna element without obstruction by an element that effectively blocks RF signals.

2. The illumination device of claim **1**, wherein the driver board includes an upper end portion those projects through the aperture of the first housing.

3. The illumination device of claim **1**, further comprising an optic element that is an enclosure that defines a lighting cavity, and wherein the lighting cavity contains the at least one lighting element.

4. The illumination device of claim **3**, wherein a portion of the driver board projects into the lighting cavity and is coated with a white solder mask.

5. The illumination device of claim **1**, wherein the aperture of the housing is located along a central axis of the illumination device.

6. The illumination device of claim **1**, wherein the aperture of the housing is located at a position that is offset from a central axis of the illumination device.

7. The illumination device of claim **1**, further comprising a second driver board that is positioned at least in part within the interior cavity of the housing.

8. The illumination device of claim **1**, further comprising a lighting element board, wherein the at least one lighting element is positioned along the lighting element board.

9. The illumination device of claim **8**, wherein the lighting element board defines a second aperture that corresponds with the aperture in the first housing.

10. The illumination device of claim **1**, further comprising a second housing, wherein the first interior cavity of the first housing is configured to receive at least a portion of the second housing and the driver board.

11. The illumination device of claim **1**, further comprising an insert ring that is constructed of an electrical insulator, and wherein the insert ring is shaped to fit within the aperture of the first housing.

12. A lighting fixture, comprising:

a first housing having an open end and a closed end, wherein an aperture is defined along a wall of the closed end;

a second housing defining a cavity and an opening, wherein the opening of the second housing is seated against the wall of the first housing;

at least one lighting element; and

a driver board electrically coupled to the at least one lighting element and including an antenna element disposed along a surface of the driver board, wherein the driver board is positioned at least in part within the cavity of the second housing and the antenna element is located within the cavity of the second housing, and wherein the aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the cavity of the second housing and are received by the antenna element without obstruction by an element that effectively blocks RF signals.

13. The lighting fixture of claim **12**, wherein the driver board includes an upper end portion and a lower end portion, wherein the upper end portion includes a first width and the lower end portion includes a second width.

14. The lighting fixture of claim **13**, wherein the first width is less than the second width.

15. The lighting fixture of claim **14**, further comprising an insert ring that is constructed of an electrical insulator, and wherein the insert ring is shaped to fit within the aperture of the first housing.

16. The lighting fixture of claim **15**, wherein the first width of the driver board transitions into the second width of the driver board using a stepped configuration which creates the two shoulder areas around an outer periphery of the driver board.

17. The lighting fixture of claim **16**, wherein a notch is located along each shoulder area of the driver board, and wherein each notch is shaped to receive a portion of the insert ring.

18. The lighting fixture of claim **12**, wherein the driver board includes an upper end portion those projects through the aperture of the first housing, and wherein the antenna element is positioned at the upper end portion of the driver board.

19. A lighting fixture, comprising:

a first housing having an open end and a closed end, wherein an aperture is defined along a wall of the closed end;

a second housing defining a cavity and an opening, wherein the opening of the second housing is seated against the wall of the first housing;

at least one lighting element; and

a driver board electrically coupled to the at least one lighting element and including an antenna element, wherein the driver board is positioned at least in part within the cavity of the second housing, and wherein the aperture of the first housing is positioned so as to create a pathway such that radio frequency (RF) signals reach the interior cavity of the first housing, the driver board comprising:

an upper end portion and a lower end portion, wherein the upper end portion includes a first width and the lower end portion includes a second width, the first width is less than the second width, wherein the first width of the driver board transitions into the second width of the driver board using a stepped configuration which creates the two shoulder areas around an outer periphery of the driver board, and wherein a notch is located along each shoulder area of the driver board; and

an insert ring that is constructed of an electrical insulator, wherein the insert ring is shaped to fit within the aperture of the first housing, and wherein each notch of the driver board is shaped to receive a portion of the insert ring.

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